



Wearable Biosensors

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Healthcare Monitoring Issue and Biosensors

- **Recalling your experience of hospital, did doctor usually ask you to do blood test?**
- **Yes!** Blood test is one way to detect concentration of chemical substances in our body.
- Moreover, result of blood test is used in aiding diagnosis directly, which reveals **the crucial status of these substances**.
- Human body contains lots of chemical substances that participates in bio-chemistry reactions of body like glucose and protein, which are called biomarkers.
- Biomarkers of body indicate state of human in terms of physiology, a normal state may be confirmed via biomarkers that are in reasonable concentration range.[1]
- However, traditional monitoring achieves **instantaneous, static and discrete** recording, it does not last a relative long time.
- Wearable biosensors have received great attention, owing to the strength of recording **real-time, simultaneous and dynamic biomarkers.**[1]

Brief history

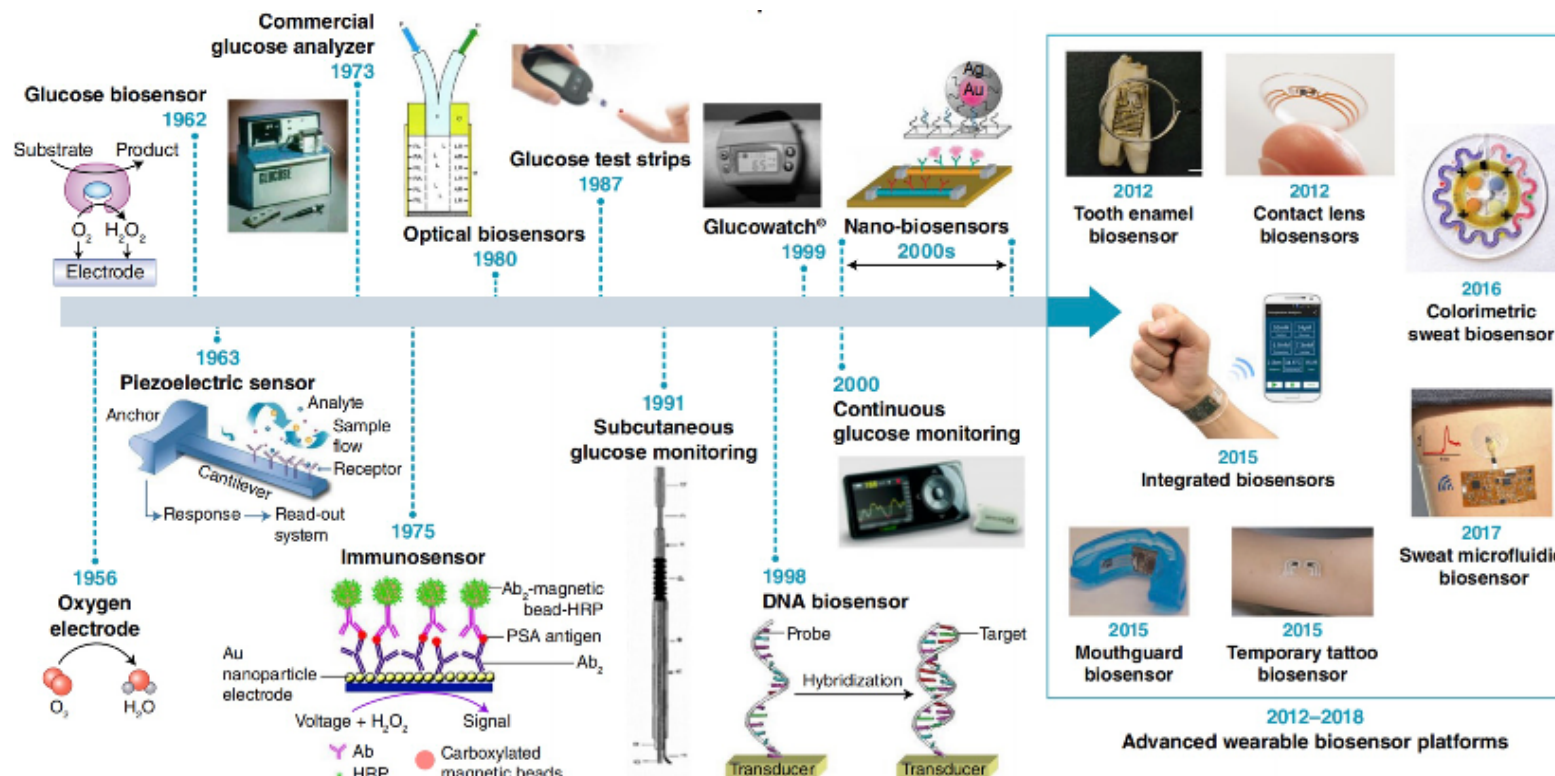


Fig. 1 | The path of biosensor development for wearable. Scheme of brief history of biosensors.
[1]

Principle

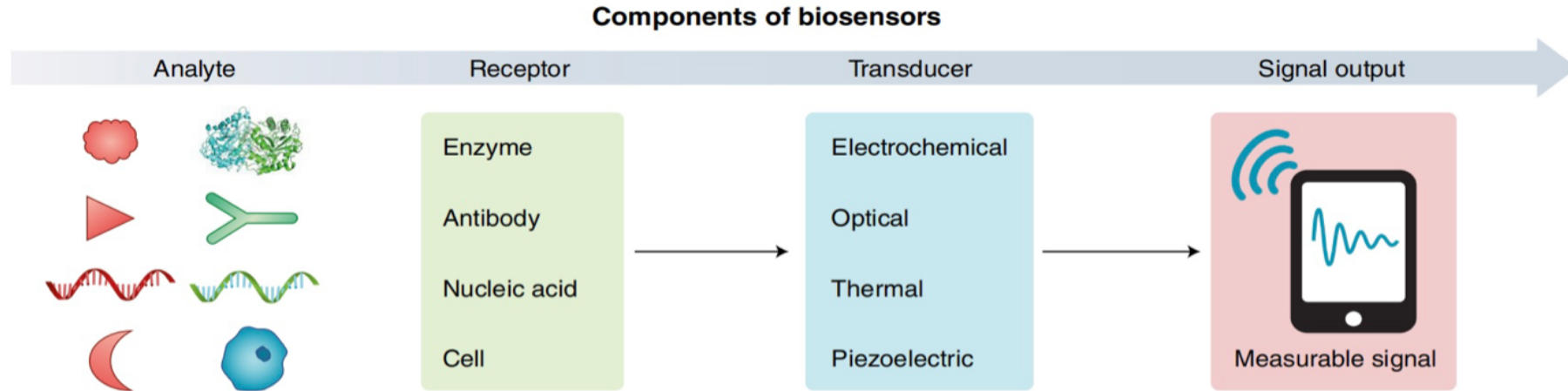


Fig. 2 | Basic parts of biosensors. Schematic representation of biosensor operation principles.[1]

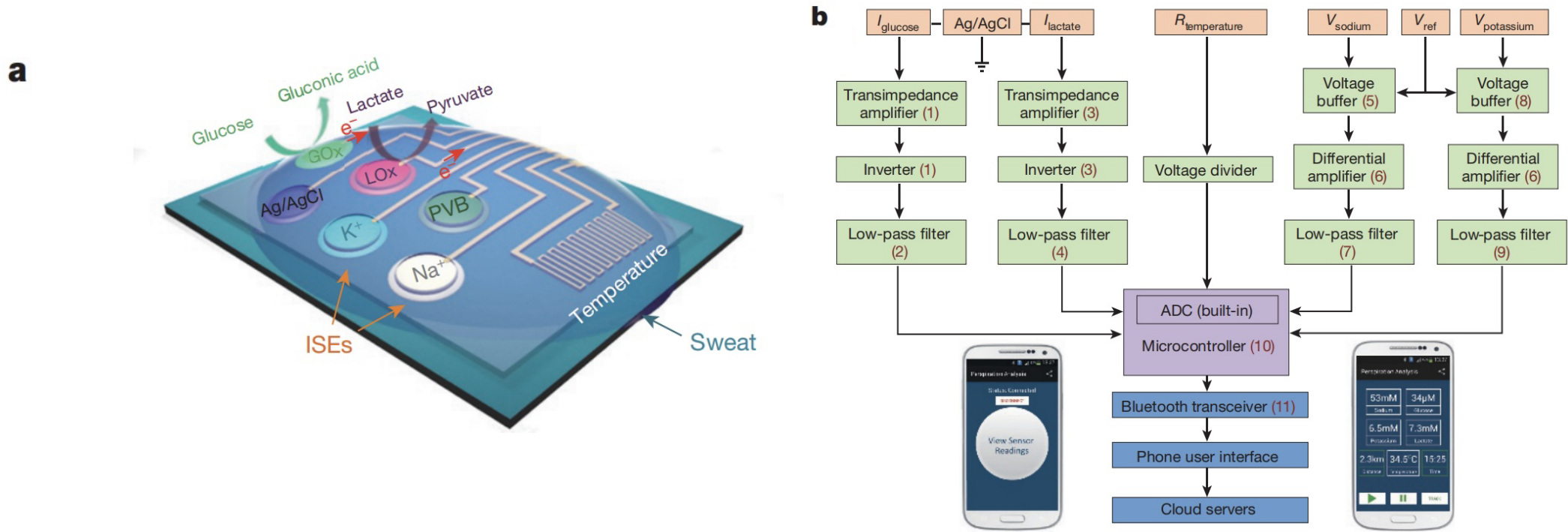


Fig. 3 | Images and schematic illustrations of the FISA for multiplexed perspiration analysis. a, Schematic of the sensor array. **b,** System-level block diagram of the biosensors showing the signal transduction.[2]

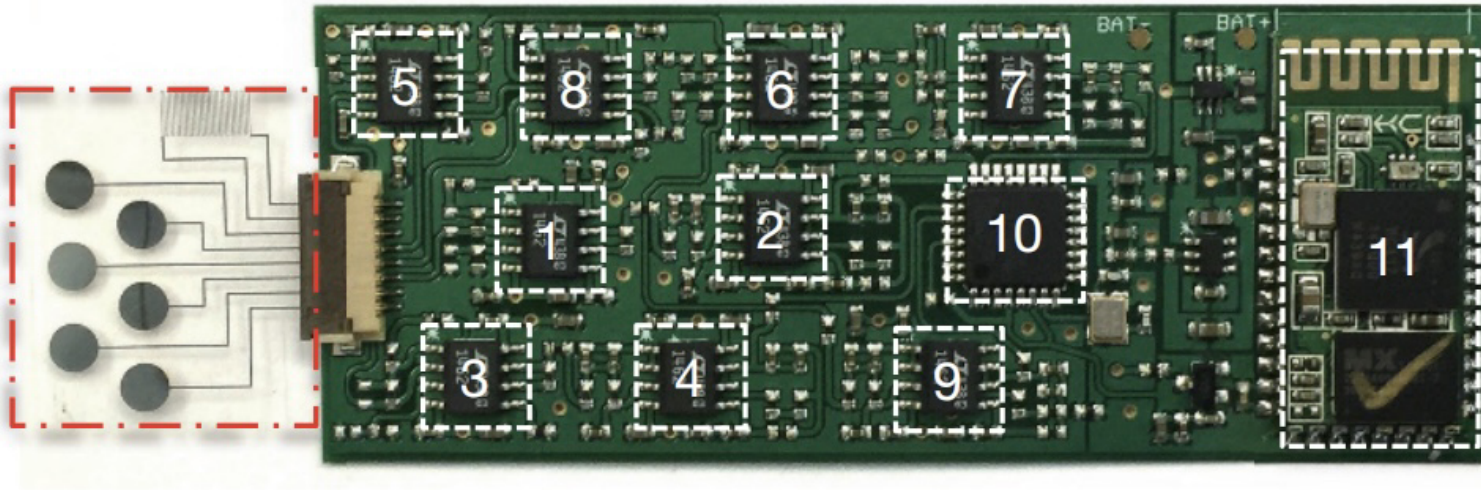


Fig. 4 | Image of the biosensor. Photograph of biosensor. The red dashed box indicates the location of the sensor array and the white dashed boxes indicate the locations of the integrated circuit components. [2]

Observation of mobile device

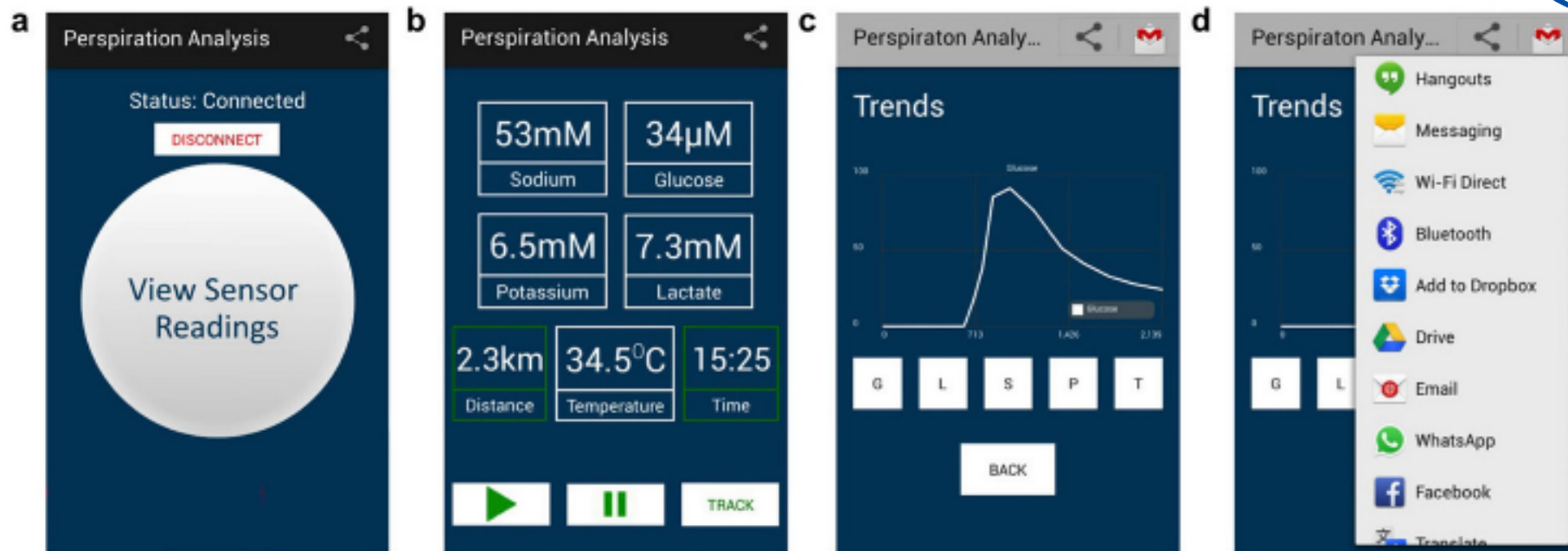


Fig. 5 | The custom-developed mobile application for data display and aggregation. a, The home page of the application after Bluetooth pairing. **b,** Real-time data display of sweat analyte levels as well as skin temperature during exercise. **c,** Real-time data progression of individual sensor. **d,** Available data sharing and uploading options.[2]



Materials

- To achieve the correct work of biosensors, materials occupy significant status.
- **Metal**
 - Ag/AgCl serves as electrode to be part of transducer that **transduces analyte signal**.
 - Cr/Au metal microwires are fabricated for sensing temperature.
 - Prussian blue dye($\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$) is used for **decreasing energy consumption**.
- **Polymer**
 - PVB, PET, PEN are used to improve elastic properties of sensors, and increase the **conformability**. [3]
 - PVB: Polyvinyl Butyral; PET: Polyethylene glycol tterephthalate; PEN: Polyethylene naphthalate
- **Carbon nanotubes** are coated on PVB polymer to protect.
- **Graphene** serves as electrode in inner structure of transducer to be more **conductable**. [4]

Evaluations and Expectations

- Temperature has greatly impact on accuracy of data collection and analysis.

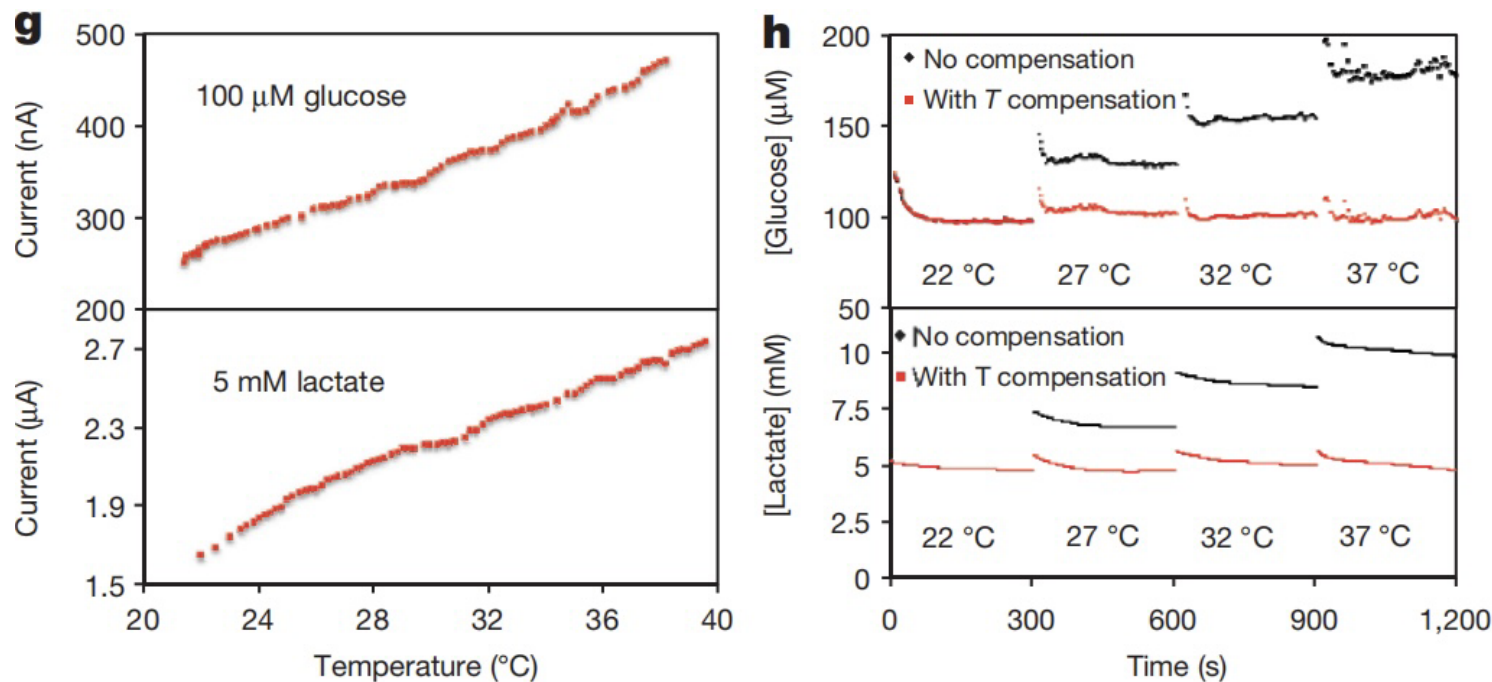


Fig. 6 | Experimental characterizations of the wearable sensors. a, The influence of temperature on the responses of the glucose and lactate sensors. **b,** System-level real-time temperature T compensation for the glucose and lactate sensors in 100- μ M glucose and 5-mM lactate solutions, respectively. [2]



Evaluations and Expectations

- Sample **contamination** (bacterial and other substance) may influence concentration of analyte.
- **Clinical value** of data should be verified via more further study and research. [1]
- It contains **great potential commerce**.
- As report predicts, global sensors market may reach \$2.86 billion by 2025.[1]



Conclusion

- Demand for monitoring concentration of biomarkers that reflect human state, scientists invented biosensors.
- Biosensors undergo development largely, which results in the advanced biosensors that monitor sweat via chemical electrodes and physical circuit.
- Advanced wearable biosensors still contains lots of backwards that means further study should be constructed.[1]
- Biosensors may occupy great market share in the future.[1]



References

[1] Kim, J., Campbell, A.S., de Ávila, B.EF. et al. Wearable biosensors for healthcare monitoring. *Nat Biotechnol* **37**, 389 – 406 (2019).

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